

### 510.1 DESCRIPTION

This work consists of furnishing, driving and cutting off timber, prestressed and steel piling, and furnishing, driving, cutting off and fastening of sheet piling and steel sheeting designated to be left in place.

### 510.2 MATERIALS

Materials shall conform to the following requirements:

- A. Timber Piles:** Section 960.
- B. Steel Piles:** ASTM A 36.
- C. Sheet Piles:** Section 1040.
- D. Steel Sheeting:** Section 1050.
- E. Prestressed Piles:** Section 560.

### 510.3 CONSTRUCTION REQUIREMENTS

#### **A. Preparation for Driving Steel and Timber Pile:**

- 1. Caps:** The heads of timber piles shall be protected by approved caps if driving is likely to damage the pile. When the area of the head of any timber pile is greater than that of the face of the hammer, a suitable cap shall be provided to distribute the hammer blow throughout the cross section of the pile.

The head shall be cut square and shaped or chamfered to prevent splitting at its periphery.

The heads of steel piles shall be cut squarely and a driving cap shall be provided to hold the axis of the pile in line with the axis of the hammer.

- 2. Collars:** Collars, bands or other devices to protect timber piles against splitting and brooming shall be provided where necessary.
- 3. Pointing:** When specified, timber piles shall be shod with metal shoes. The points of the piles shall be carefully shaped to secure an even and uniform bearing on the shoes. After shaping, exposed untreated wood shall be retreated in the field in accordance with Section 510.3.G.
- 4. Splicing Piles:** Splices shall be made in accordance with the details. Indiscriminate use and location of splices is prohibited. The proposed location of splices used in conjunction with frame pile bents and integral type abutments will require prior approval. All splices shall be welded by a certified welder in accordance with Section 410.

- 5. Preboring:** Preboring shall be done when specified on the plans or directed by the Engineer.

Holes for timber piles shall be a minimum of two inches (50 mm) larger than the nominal diameter of the pile. The nominal diameter shall be measured three feet (1 meter) from the butt of the pile.

Holes for steel piles shall be not less than the following specified diameter:

8 HP (HP200) Piles*	12 inches (300 mm)
10 HP (HP250) Piles*	15 inches (375 mm)
12 HP (HP310) Piles*	18 inches (450 mm)
14 HP (HP360) Piles*	21 inches (525 mm)

\*All Weights

After the piles are driven, the prebored holes shall be backfilled with coarse dry sand. The sand shall be compacted to prevent bridging.

- When specified, steel piles shall be equipped with tip reinforcement. Installation shall be per manufacturer recommendation.

## B. Method of Driving

- General:** Piles may be driven with a steam or air hammer, a gravity hammer, a diesel hammer or a combination of water jets and hammer.
- Hammers for Timber and Steel Piles:** Gravity hammers shall weigh not less than 3000 pounds (1360 kg), and the weight of the hammer shall not be less than the combined weight of the driving head and pile. The fall shall be regulated to avoid damage to the piles, and shall not exceed 10 feet (3 meter).

The total energy, as per manufacturer's rating, developed by mechanically powered hammers shall not be less than that required to achieve design bearing using the equations of Section 510.3.D.2 assuming the following conditions.

Penetration per Blow (S)	=0.10 in/blow (2.54 mm/blow)
Hammer Operating Efficiency	= 85% for diesel hammers
	= 95% for air/steam hammers

- Additional Equipment:** If the required penetration is not obtained with a hammer complying with the above requirements, the Contractor shall provide a heavier hammer or resort to jetting at no additional cost.

Unless otherwise approved, the penetration for any pile shall not be less than eight feet (2.5 meter).

- Leads:** Pile leads shall be constructed to afford freedom of movement of the hammer. Inclined leads shall be used in driving battered piles.

5. **Water Jets:** When water jets are used, the number of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the pile. The pumping plant shall have capacity to deliver and maintain at least 100 psi (0.7 MPa) hydraulic pressure at two jet nozzles. Before the desired penetration is reached, the jet shall be withdrawn and the piles shall be driven with the hammer to secure the final penetration and bearing. The final penetration by driving shall be a minimum of five feet (1.5 meter) or to refusal.
6. **Accuracy of Driving:** Piles shall be driven with a variation of not more than 1/4 inch per foot (20 mm/m) from the vertical or from the batter specified. Foundation piles shall not be driven out of position by more than six inches (150 mm).

#### C. Defective Piles:

The procedure for driving piles shall prevent excessive and undue abuse producing injurious splitting, splintering or brooming of the wood or deformation of the steel. Manipulation of piles to force them into proper position will not be permitted. Piles damaged by internal defects, or improper driving; or driven out of its proper location or driven below the specified elevation shall be corrected by withdrawing the pile and replacing it with a new pile. If withdrawing the pile cannot be done or is impractical, the Bridge Construction Engineer shall be contacted for further direction.

#### D. Determination of Bearing Value of Piles:

1. The bearing value of piles will be determined by static load tests when specified. Testing shall follow ASTM D1143. The specific testing procedure shall be approved prior to driving.
2. When load tests are not specified the bearing value of piles shall be computed from the following formulas:

(English)

a. For Gravity Hammers: 
$$P = \frac{3WH}{S+0.35} \times \frac{W}{W+M}$$

b. For Double Action  
Steam or Air Hammers  
and Closed Cylinder 
$$P = \frac{3E}{S+0.1} \times \frac{W}{W+M}$$
  
Top Diesel Hammers:

c. For Single Action  
Steam or Air Hammers  
and Open Cylinder 
$$P = \frac{3WH}{S+0.1} \times \frac{W}{W+M}$$
  
Top Diesel Hammers:

The following applies to these formulas:

**P** = the bearing value in tons.

**W** = the weight of a gravity hammer, or the ram of an energy hammer in tons.

**H** = the height of free fall of the hammer or ram in feet.

**M** = the weight in tons of the driven mass and shall include the weight of the pile, the weight of the driving cap and the weight of the anvil, if used.

**E** = the energy per blow in foot tons.

**S** = the average penetration in inches of the pile per blow for the last five blows for gravity hammers and the last 10 blows for energy hammers.

**(METRIC)**

a. For Gravity Hammers: 
$$P = \frac{2.5WH}{S+8.9} \times \frac{W}{W+M}$$

b. For Double Action  
Steam or Air Hammers  
and Closed Cylinder 
$$P = \frac{0.25E}{S+2.5} \times \frac{W}{W+M}$$
  
Top Diesel Hammers:

c. For Single Action  
Steam or Air Hammers  
and Open Cylinder 
$$P = \frac{2.45WH}{S+2.5} \times \frac{W}{W+M}$$
  
Top Diesel Hammers:

The following applies to these formulas:

**P** = the bearing value in kilonewtons.

**W** = the mass of a gravity hammer, or the ram of an energy hammer in kilograms.

**H** = the height of free fall of the hammer or ram in meters.

**M** = the driven mass in kilograms and shall include the mass of pile, the mass of the driving cap and mass of anvil, if used.

**E** = the energy per blow in joules.

**S** = the average penetration in millimeters of the pile per blow for the last five blows for gravity hammers and the last 10 blows for energy hammers.

3. The formulas shall be applied for compliance with the following conditions:

- a. Unless the hammer has free fall, the value substituted for "W" shall be less than the weight of the hammer by an amount sufficient to compensate for all friction and drag tending to retard its fall.
- b. The head of the pile shall be free from broomed or crushed fibers.
- c. The penetration of the pile is at a reasonably quick and uniform rate.
- d. There is no excessive bounce to the hammer after the blow.
- e. The value of "H" shall be less than the height of fall of the hammer by twice the height of the bounce.

- f. For the computation of the bearing value for battered piles, the value obtained from the formulas shall be multiplied by the following factor:
- (Cosine a) minus (f sine a). Where "a" equals the angle which the leads make with the vertical and "f" equals the coefficient of friction between the hammer or ram and the surface on which it slides. For gravity hammers sliding on greased steel surfaced leads or energy hammers, the value of "f" shall be assumed to be 0.1.
4. When the required bearing for a pile can not be obtained without splicing, driving shall be stopped when the top of the pile is approximately two feet (600 mm) above cut-off elevation. After a minimum delay of 24 hours, the driving may be resumed and the bearing rechecked to determine the amount of setting-up effect. The amount of setting-up effect may be considered in determining the bearing value for the remainder of the piles, in the same bent or abutment, that cannot be driven to bearing without splicing, provided they have an initial bearing equal to or greater than the pile checked.
- E. Test Piles:** The Contractor shall drive test pile of the lengths shown on the plans and at locations directed. The Contractor shall cooperate with the Engineer in facilitating the keeping of accurate records of driving and shall drive test piles to the bearing ordered by the Engineer. Test piles shall be driven to no more than 120% of the plans required bearing.
- F. Bearing Piles:** Bearing pile shall be furnished at the specified length, and driven to the required bearing and location as shown on the plans. Bearing piles shall be driven to no more than 110% of the plans required bearing.
- G. Storage and Handling of Timber Piles:** Timber piles shall be handled and stored to prevent damage and avoid breaking the surface of treated piles. Cuts or breaks, which expose untreated wood, shall be given three brush coats of hot creosote.
- H. Cutting Off Piles:** The tops of all piling shall be cut off to a true plane at the specified elevation.
- The length of pile above the elevation of the cut-off shall be sufficient to permit the complete removal of all material damaged by driving. Timber piles driven to very nearly the cut-off elevation shall be carefully adzed or otherwise freed from broomed, splintered or otherwise damaged material.
- Undamaged cut-off material with a length greater than five feet (1.5 m) may be spliced to satisfy minimum pile length requirements. Unused pile cutoffs shall become the property of the Contractor. The cutoff ends shall be retreated in the field in accordance with Section 510.3.G.
- I. Sheet Piling and Steel Sheeting:** Driving shall be accomplished so the piles or sheeting are firmly fixed in assembly to the line desired and all joints are watertight.

## 510.4 METHOD OF MEASUREMENT

- A. Test Piles:** The length of test piles remaining in the completed structure will be measured to the nearest foot (0.1 meter).
- B. Bearing Piles:** The length of bearing piles remaining in the completed structure will be measured to the nearest lineal foot (0.1 meter). Quantity for test pile will not be included in the measurement of pay footage for bearing piles.
- C. Splices:** Splices ordered will be measured on a per each basis. Pile splices located within the pile length called for on the plans will not be measured. The number of splices to be measured for payment will be those located at or beyond the length specified necessary to increase the length of a pile incorporated into the structure over the length specified.
- D. Pile Shoes:** Pile shoes will be measured by the unit complete in place.
- E. Load Tests:** Piling load tests will be measured on a per each basis.
- F. Preboring Piling:** Prebored holes for piling will be measured to the nearest foot (0.1 meter) of depth. Holes of different diameters will be measured under the same item.
- G. Pile tip reinforcement** will be measured by the unit.
- H. Sheet Piling and Steel Sheeting:** The quantity of sheet piling or steel sheeting furnished complete in place will be computed to the nearest square foot (0.1 square meter). Cut-off material will not be measured for payment. The horizontal measurement used in computing the area will be taken along the alignment of the piling or sheeting to the nearest 0.1 foot (10 mm) without any allowance for the structure shape of the section. The vertical measurement used in computing the area will be the final length to the nearest 0.1 foot (10 mm).

### 510.5 BASIS OF PAYMENT

- A. Test Piles:** Test pile will be paid for at the contract unit price per lineal foot (0.1 meter). If the plans quantity is greater than the actual quantity driven, the plans quantity will be used for payment. This payment will be full compensation for all labor, equipment, and incidentals necessary for furnishing and driving the test pile.
- B. Bearing Piles:** The furnishing and driving of bearing pile will be paid for at the respective contract unit price per lineal foot (0.1 meter). This payment will be full compensation for all labor, equipment, and incidentals necessary to furnish and satisfactorily drive the bearing pile. When the final in-place quantity of each size of bearing pile driven and accepted for payment varies from the plans quantity, the Contractor will be compensated for the difference as follows:
  - 1.** When the final quantity of each size underruns the total contract quantity by more than five feet times the number of piles, the Contractor will receive 20% of the contract unit price for the entire difference in quantity.

2. When the final quantity of each size overruns the plans quantity, the Contractor will receive the contract unit price plus 10% for the excess over plans quantity.

The provisions of Section 9.6 shall not apply for overruns and underruns in bearing pile quantity.

**C. Cut-off:** Payment will not be made for pile cut-offs.

**D. Splices:** Splices will be paid for as specified in the Price Schedule for Miscellaneous Items.

**E. Pile Shoes:** This item will be paid for at the contract unit price per each. Payment shall be full compensation for furnishing and installing pile shoes.

Payment for pile shoes, when a bid item does not exist, will be made at the price specified in the Price Schedule for Miscellaneous Items.

**F. Load Tests:** Payment for load tests will be made at the contract unit price per each. Payment will be full compensation for assisting the Engineer in making load tests and for delays caused by tests. Delays shall not exceed 60 consecutive hours for each pile tested, beginning when loading operations are started. The apparatus, transportation of the apparatus to and from the site of the work and personnel for conducting the tests will be furnished by the Department.

Payment for load tests when a bid item does not exist will be made at the price specified in the Price Schedule for Miscellaneous Items.

**G. Preboring Piling:** This work will be paid for at the contract unit price per foot (0.1 meter). Payment will be full compensation for satisfactorily preboring and backfilling holes for piling.

When preboring is necessary and no bid item exists, payment will be made as extra work.

**H. Pile Tip Reinforcement:** This item will be paid for at the contract unit price per each. Payment will be full compensation for furnishing and installing pile tip reinforcement.

Payment for pile tip reinforcement, when a bid item does not exist, will be made at the price specified in the Price Schedule for Miscellaneous Items.

**I. Sheet Piling and Steel Sheeting:** This work will be paid for at the contract unit price per square foot (0.1 square meter) for the various kinds of sheet piling and steel sheeting. Payment will be full compensation for furnishing and placing the piling or steel sheeting.

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